

CLAIMS

1. A cell for electrowinning aluminium from alumina, comprising:
  - a metal-based anode having an outer part that contains at least one of nickel, cobalt and iron, the outer part having an electrochemically active oxide-based surface; and
  - a fluoride-containing molten electrolyte in which the active anode surface is immersed, the electrolyte being at a temperature below 950°C, in particular in the range from 910° to 940°C, and consisting of:
    - 6.5 to 11 weight% dissolved alumina;
    - 35 to 44 weight% aluminium fluoride;
    - 38 to 46 weight% sodium fluoride;
    - 2 to 15 weight% potassium fluoride;
    - 0 to 5 weight% calcium fluoride; and
    - 0 to 5 weight% in total of one or more further constituents.
2. The cell of claim 1, wherein the electrolyte contains 7 to 10 weight% alumina.
3. The cell of claim 1 or 2, wherein the electrolyte contains 36 to 42 weight% aluminium fluoride, in particular 36 to 38 weight%.
4. The cell of any preceding claim, wherein the electrolyte contains 39 to 43 weight% sodium fluoride.
5. The cell of any preceding claim, wherein the electrolyte contains 3 to 10 weight% potassium fluoride, in particular 5 to 7 weight%.
6. The cell of any preceding claim, wherein the electrolyte contains 2 to 4 weight% calcium fluoride.
7. The cell of any preceding claim, wherein the electrolyte contains up to 3 weight% of said one or more further constituents.
8. The cell of any preceding claim, wherein said one or more further constituents comprise at least one fluoride selected from magnesium fluoride, lithium fluoride, cesium fluoride, rubidium fluoride, strontium fluoride, barium fluoride and cerium fluoride.

9. The cell of any preceding claim, wherein the electrolyte contains alumina at a concentration near saturation on the active anode surface.
10. The cell of any preceding claim, comprising a cathode that has an aluminium-wettable surface, in particular a horizontal or inclined drained surface.
11. The cell of claim 10, wherein the cathode has an aluminium-wettable coating that comprises a refractory boride and/or an aluminium-wetting oxide.
12. The cell of any preceding claim, wherein the anode has a metallic or cermet body and an oxide layer on the anode body.
13. The cell of any preceding claim, wherein the anode consists predominantly of iron and is optionally covered with an integral iron oxide-based layer.
14. The cell of claim 13, wherein the anode body is made from an alloy consisting of:  
- 65 to 95 weight% iron, in particular 75 to 90 weight%;  
- 2 to 10 weight% aluminium, in particular 3 to 6 weight%;  
- 0 to 5 weight% niobium, in particular 2 to 4 weight%;  
- 0 to 3 weight% hafnium, in particular 1 to 2 weight%;  
- 0 to 15 weight% in total of nickel and/or cobalt, in particular 0 to 10 weight%;  
- 0 to 6 weight% copper, in particular 0 to 4 weight%;  
and  
- 0 to 2 weight% in total of further constituents, in particular 0.5 to 1 weight%.
15. The cell of any one of claims 1 to 12, wherein the anode body is made from a nickel and/or cobalt-based alloy.
16. The cell of claim 15, wherein the anode body is made from an alloy consisting of:  
- 50 to 65% in total of nickel and/or cobalt, in particular 55 to 60 weight%;  
- 25 to 40 weight% iron, in particular 30 to 35 weight%;  
- 3 to 11 weight% copper, in particular 5 to 9 weight%;  
- 1 to 3 weight% aluminium, in particular 2 to 3 weight%;  
- 0 to 2 weight% niobium, in particular 0 to 1 weight%;

- 0 to 2 weight% hafnium, in particular 0 to 1 weight%; and
- 0 to 2 weight% in total of further constituents, in particular 0.5 to 1 weight%.

5       17. The cell of claim 15 or 16, wherein the anode body  
is covered with an integral iron oxide-based layer  
containing oxides of iron and at least one of nickel and  
cobalt oxides, and optionally at least one oxide of one  
or more further metals, present in the following amounts  
10      calculated as weight% of the metals:  
- 65 to 99 weight% iron, in particular 80 to 95 weight%;  
- 1 to 35 weight% in total of nickel and/or cobalt, in  
particular 5 to 20 weight%; and  
- 0 to 3 weight% in total of said one or more further  
15      metals, in particular 0 to 1.5 weight%.

18. The cell of any preceding claim, wherein the anode  
comprises an applied iron oxide-based coating.

19. The cell of claim 18, wherein the anode coating  
contains  $\text{Fe}_2\text{O}_3$  and optionally: at least one dopant  
20      selected from  $\text{TiO}_2$ ,  $\text{ZnO}$  and  $\text{CuO}$  and/or at least one inert  
material selected from nitrides and carbides.

20. The cell of any preceding claim, wherein the anode  
is coated with a cerium oxyfluoride-based outermost  
coating.

25    21. The cell of any preceding claim, wherein the anode  
is suspended in the electrolyte by a stem containing  
nickel and/or iron.

30    22. The cell of claim 21, wherein the stem has a core  
containing nickel and/or iron which is covered with an  
applied oxide coating, in particular an applied coating  
containing aluminium oxide and titanium oxide.

23. The cell of claim 21 or 22, wherein the core of the  
stem comprises a copper-based inner part and an outer  
part containing nickel and/or iron.

35    24. The cell of any preceding claim, comprising at  
least one component that contains a sodium-active  
cathodic material, such as elemental carbon, said  
sodium-active cathodic material being shielded from the  
electrolyte by a sodium-inert layer to inhibit the  
40      presence in the molten electrolyte of soluble

cathodically-produced sodium metal that constitutes an agent for dissolving the active oxide-based anode surface.

25. A cell according to claim 1, comprising:

- 5    A) a metal-based anode having an outer part that has an electrochemically active oxide-based surface and that is made from an alloy consisting of:
  - 75 to 90 weight% iron;
  - 3 to 6 weight% aluminium;
  - 0 to 4 weight% in total of niobium and/or hafnium;
  - 0 to 10 weight% in total of nickel and/or cobalt;
  - 0 to 4 weight% copper; and
  - 0.5 to 1 weight% in total of further constituents;  
or
  - 55 to 60 weight % in total of nickel and/or cobalt;
  - 30 to 35 weight% iron;
  - 5 to 9 weight% copper;
  - 2 to 3 weight% aluminium;
  - 0 to 1 weight% in total of niobium and/or hafnium;
  - and
  - 0.5 to 1 weight% in total of further constituents;
- 10    B) an anode stem for suspending the anode in the electrolyte, the stem containing nickel and/or iron and being covered with a coating of aluminium oxide and titanium oxide;
- 15    C) a fluoride-containing molten electrolyte in which the active anode surface is immersed and which is at a temperature in the range from 910° to 940°C and which consists of:
  - 7 to 10 weight% dissolved alumina;
  - 36 to 42 weight% aluminium fluoride;
  - 39 to 43 weight% sodium fluoride;
  - 3 to 10 weight% potassium fluoride, in particular 3 to 7 weight%;
  - 2 to 4 weight% calcium fluoride; and
  - 0 to 3 weight% in total of one or more further constituents;
- 20    and
- 25    D) a cathode having an aluminium-wettable surface, in particular a drained horizontal or inclined surface, formed by an aluminium-wettable coating of refractory hard material and/or aluminium-wetting oxide.

26. A method of electrowinning aluminium in a cell as defined in any preceding claim, comprising electrolysing the dissolved alumina to produce oxygen on the anode and aluminium cathodically, and supplying alumina to the 5 electrolyte to maintain therein a concentration of dissolved alumina of 6.5 to 11 weight%, in particular 7 to 10 weight%.
27. An aluminium electrowinning anode made from an alloy consisting of:
- 10 - 65 to 95 weight% iron, in particular 75 to 90 weight% or 90 to 95 weight%;  
- 2 to 10 weight% aluminium, in particular 3 to 6 weight% or 5 to 10 weight%;  
- 0 to 5 weight% niobium, in particular 2 to 4 weight%;  
15 - 0 to 3 weight% hafnium, in particular 1 to 2 weight%;  
- 0 to 15 weight% in total of nickel and/or cobalt, in particular 0 to 10 weight%;  
- 0 to 6 weight% copper, in particular 0 to 4 weight%;  
and  
20 - 0 to 2 weight% in total of further constituents, in particular 0.5 to 1 weight%, wherein the total amount of niobium, hafnium and further constituents is in the range from 0.25 to 3 weight%, in particular 0.75 to 2.5 weight%.
25. 28. An aluminium electrowinning anode made from an alloy consisting of:  
- 50 to 65% in total of nickel and/or cobalt, in particular 55 to 60 weight%;  
- 25 to 40 weight% iron, in particular 30 to 35 weight%;  
30 - 3 to 9 weight% copper, in particular 5 to 7 weight%;  
- 1 to 3 weight% aluminium, in particular 2 to 3 weight%;  
- 0 to 2 weight% niobium, in particular 0 to 1 weight%;  
- 0 to 2 weight% hafnium, in particular 0 to 1 weight%;  
35 and  
- 0 to 2 weight% in total of further constituents, in particular 0.5 to 1 weight%, wherein the total amount of niobium, hafnium and further constituents is in the range from 0.25 to 5 weight%, in particular 1.5 to 3 weight%.